A heat exchanger plate and a plate package

BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention refers to a heat exchanger plate for a plate package for a plate heat exchanger, wherein the heat exchanger plate extends between a primary edge zone and a secondary edge zone in parallel with a central extension plane, an upper plate plane and a lower plate plane, wherein the central extension plane includes a centre axis dividing the heat exchanger plate in a primary part and a secondary part, and wherein the heat exchanger plate includes a first end area, a second end area, a central heat transfer area, which extends between the primary edge zone and the secondary edge zone from the first end area to the second end area, a primary porthole and a secondary porthole, which extend through the heat exchanger plate in the first end area and which are surrounded by a respective adjoining edge area, wherein the primary porthole is located on the primary part and the secondary porthole on the secondary part, and a distribution area which extends on the first end area and has a base surface extending from the primary porthole to the central heat transfer area.

The invention also refers to a plate package for a plate heat exchanger including at least two heat exchangers plates with a plate interspace therebetween, wherein each heat exchanger plate extends between a primary edge zone and a secondary edge zone in parallel with a central extension plane, an upper plate plane and a lower plate plane, wherein the central

extension plane includes a centre axis dividing the heat exchanger plate in a primary part and a secondary part, and wherein the heat exchanger plate includes a first end area, a second end area, a central heat transfer area, which extends between the primary edge zone and the secondary edge zone from the first end area to the second end area, a primary porthole and a secondary porthole, which extend through the heat exchanger plate in the first end area and which are surrounded by a respective adjoining edge area, wherein the primary porthole is located on the primary part and the secondary porthole on the secondary part, and a distribution area which extends on the first end area and has a base surface extending from the primary porthole to the central heat transfer area.

In such plate heat exchangers, it is desirable that the main heat transfer takes place at the central heat transfer area of the plates. The distribution areas which adjoin the portholes have the function of distributing the media in a uniform manner to the central heat transfer area in such way that the heat transfer takes place uniformly over the whole central heat transfer area. It is known to provide such a distribution by means of special corrugations of the distribution area. These corrugations guide the media flow in such a way that it is uniformly distributed to the central heat transfer area. A disadvantage of such known distribution patterns is that they also contribute to a too large pressure drop over the distribution area. Such a pressure drop deteriorates the efficiency of the plate heat exchanger and contributes to a too large heat transfer outside the central heat transfer area.

A limitation in this context is the strength of the plate heat exchanger in the distribution area. In plate heat exchangers where the heat exchanger plates are permanently joined to each other, for instance by brazing, strong tensile stresses arise in the plate package when media under high pressure is conveyed

through the plate heat exchanger. In plate heat exchangers compressed between a frame plate and a pressure plate, strong compressive stresses arise in the plate package due to the pretensioning. In order to resist such tensile stresses and compressive stresses in the distribution area, there must be a certain number of contact points or contact spots between adjacent heat exchanger plates. In brazed plate heat exchangers, the heat exchanger plates are joined to each other at these points or spots. In order to resist the different kind of stresses it is also important that these contact points are arranged substantially straight above each other, i.e. that they form an as straight as possible line through the whole plate package.

SE-B-415 928 discloses a plate heat exchanger having a number of heat exchanger plates which each extends in parallel to a central extension plane. Each plate includes a first end area having a primary porthole and a secondary porthole, a second end area having a primary porthole and a secondary porthole, and central heat transfer area, which extends from the first end area to the second end area. The portholes for the inlet and the outlet of one and the same fluid are arranged at the same side of the plate. The central heat transfer area has a corrugation, which creates a number of passages designed in such a way that the passages are thinner at the side of the plate where the inlet and the outlet for the same fluid are located.

WO85/02670 discloses a plate heat exchanger having a number of heat exchangers plates which each extends in parallel to a central extension plane. Each plate includes a first end area having a primary porthole and secondary porthole, a second end area having a primary porthole and a secondary porthole, and central heat transfer area, which extends from the first end area to the second end area. The portholes for the inlet and the outlet for one and the same fluid are arranged at the same side of the plate. A first distribution area extends on the first end area and

a second distribution area extends on the second end area. The distribution areas and the central heat transfer area have corrugations extending in such directions that the flow resistance in the plate interspaces between the distribution areas is smaller than the flow resistance in the plate interspaces between the central heat transfer areas.

GB-A-2 054 817 discloses a plate heat exchanger having a number of heat exchanger plates, which each extends between a left edge and a right edge in parallel to a central extension plane, an upper plate plane and a lower plate plane. The central extension plane includes a centre axis dividing the plate in a left part and a right part. The plate includes a first end area, a second end area and a central heat transfer area, which extends between the left edge and the right edge from the first end area to the second end area. An inlet porthole and an outlet porthole extend through the plate in the first end area and are surrounded by a respective adjoining edge area. The inlet porthole is located on the left part and the outlet porthole on the right part. A distribution area extends from the first end area and has a base surface which appears to be parallel to the central extension plane and which extends from the inlet porthole to the heat transfer area. On this base surface one or several separated distribution members are attached. The distribution member is designed in such a way that it is located at an upper level in the proximity of the upper plate plane in the proximity of the edge area of the inlet porthole and sinks successively to a lower level in the proximity of the lower plate plane in the proximity of the left edge.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a heat exchanger plate intended for a plate package in a plate heat exchanger and including an improved distribution area.

A further object of the present invention is to provide such a heat exchanger plate contributing to a low flow resistance in the distribution area.

A further object of the present invention is to provide such a heat exchanger plate that contributes to a high strength for the plate heat exchanger in the distribution area.

This object is achieved by the heat exchanger plate initially defined, which is characterised in that the base surface is located at an upper level in the proximity of the upper plate plane in the proximity of the edge area of the primary porthole and sinks successively to a lower level in the proximity of the lower plate plane in the proximity of the secondary edge zone. By such a design of the distribution area, the plate interspace between two heat exchanger plates in the plate package may obtain an increasing flow area with an increasing distance from the primary porthole forming the inlet port of the plate package. More precisely, the height of the plate interspace will be relatively small in an area close to the inlet port and increase successively in a direction towards the opposite secondary edge zone. This design contributes to a uniform distribution of the medium which enters via the primary porthole over the whole inlet to, i.e. the width of, the central heat transfer area.

According to a further embodiment of the invention, the shape of the distribution area is produced through a compression-moulding of the heat exchanger plate. In such a way, this advantageous design of the distribution area may also be obtained in an easy manner to a low cost. No further components or elements are needed in the plate package.

According to a further embodiment of the invention, the base surface sinks successively along a border to the central heat transfer area from in the proximity of the primary edge zone to in the proximity of the secondary edge zone. In such a way, the

flow resistance of the medium to the more remote parts of the distribution area may, seen from the primary porthole where the media is intended to enter, be reduced so that a uniform distribution of the media along the whole central heat transfer area is achieved.

According to a further embodiment of the invention, the base surface sinks continuously from the upper level to the lower level. It is to be noted that by the expression "successively" not only such a continuous sinking of the base surface is intended but also for instance a gradually sinking of the base surface in such a way that the base surface forms a plurality of gradually lower portions which each is substantially parallel to the central extension plane. The continuous sinking mentioned above may be obtained by a substantially plane base surface or a somewhat curved base surface.

According to a further embodiment of the invention, the distribution area and the base surface extend over substantially the whole first end area.

According to a further embodiment of the invention, the distribution area includes a number of projections and depressions, wherein substantially each projection extends in a respective direction running from the primary porthole towards the central heat transfer area. Such projections will thus guide the medium flowing from the primary porthole towards the central heat transfer area. Advantageously, substantially each projection may reach the upper plate plane and substantially each depression may reach the lower plate plane. In such a way, the projections and depressions of adjacent heat exchanger plates in the plate package may form mutual supports to each other in the form of points, lines or areas.

According to a further embodiment of the invention, substantially each projection has a length which is substantially shorter than

the distance from the primary porthole to central heat transfer area along the direction of the projection.By means of the shortening of the projections in this way, the medium will not be confined in channels between the projections but may flow freely and in such a way be distributed in a better way over the whole distribution area. Furthermore, the flow resistance may be kept at a low level by means of such short projections.

According to a further embodiment of the invention, substantially each depression extends substantially perpendicular to said respective direction of an adjacent projection. The depressions have a very small influence on the flow. The depressions project, however, into the adjacent plate interspace and guide the medium that flows therein from the secondary part to the primary part with regard to this heat exchanger plate. Substantially each depression may then extend in a respective direction running from the secondary porthole towards the central heat transfer area. Also substantially each depression has advantageously a length which is substantially shorter than the distance from the secondary porthole to the central heat transfer area along the direction of the depression.

According to a further embodiment of the invention, each projection and each depression have two ends and two long sides, wherein substantially each projection, which is located on the secondary part, with one of the ends extends to one of the long sides of a depression, and wherein substantially each depression, which is located on the primary part, with one of the ends extends to one of the long sides of a projection. By such a location of the projections and depressions, a relatively free flow is achieved for the media flowing through the plate package and at the same time favourable support points are formed between adjacent heat exchanger plates. In particular, it is to be noted that the support points or support lines are located in such a way that they lie substantially straight above each other through the whole plate package. Such a support line extending

substantially straight through the whole plate package is especially advantageous for absorbing the tensile stresses arising in a plate heat exchanger where the plates are permanently joined to each other through for instance brazing, or the compressive stresses arising in a plate heat exchanger where the plates are pressed against each other.

According to a further embodiment of the invention, the heat exchanger plate is symmetric with regard to the centre axis in such a way that most of the depressions have a shape and a position corresponding to the shape and the position of a projection on the other side of the centre axis, wherein each depression is design to abut a projection of an adjacent turned heat exchanger plate in the plate package.

The object is also achieved by the plate package initially defined, which is characterised in that the base surface is located at an upper level in the proximity of the upper plate plane in the proximity of the edge area of the primary porthole and sinks successively to a lower level in the proximity of the lower plate plane in the proximity of the secondary edge zone. By such a design of the distribution area, the plate interspace will have an increasing flow area with an increasing distance from the primary porthole forming the inlet port of the plate package. More precisely, the height of the plate interspace will be relatively small in an area close to the inlet port and increase successively in a direction towards the opposite secondary edge zone. In such a way, a uniform distribution of the medium, which enters via the primary porthole channel over the whole inlet to the central heat transfer area, is achieved.

Advantageous embodiments of the plate package are defined in the dependent claims 15 to 26. Advantageously, the heat exchanger plates may then be arranged in an alternating order in such a way that the primary part at the first end area of a first heat exchanger plate adjoins the secondary part of an adjacent

second heat exchanger plate, wherein the height of the plate interspace decreases successively from in the proximity of the edge area of the primary porthole with regard to the first heat exchanger plate to in the proximity of the secondary edge zone with regard to the first heat exchanger plate. This height may decrease continuously or gradually. Furthermore, it is to be mentioned that the heat exchanger plates may be arranged in an alternating order in such a way that the primary part at the first end area of a first heat exchanger plate adjoins the secondary part of an adjacent second heat exchanger plate, wherein substantially each depression of the first heat exchanger plate abuts a projection of the adjacent second heat exchanger plate. The heat exchanger plates may advantageously be permanently joined to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now to be explained more closely through a description of various embodiments, disclosed by way of example, and with reference to the drawings attached hereto.

Fig. 1 discloses schematically an elevation view of a plate heat exchanger according to an embodiment of the invention.

Fig. 2 discloses schematically a side view of the plate heat exchanger in Fig. 1.

Fig. 3 discloses schematically an elevation view of the heat exchanger plate of the plate heat exchanger in Fig. 1.

Fig. 4 discloses a cross-sectional view through a plate package with heat exchanger plates along the line IV-IV in Fig. 3.

Fig. 5 discloses schematically a side view of a plate heat exchanger according to a second embodiment of the invention.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS OF THE INVENTION

Figs. 1 and 2 disclose schematically a plate heat exchanger according to a first embodiment of the invention. The plate heat exchanger includes a number of heat exchanger plates 1, see Fig. 3, which are arranged beside each other in such a way that they form a plate package 2. In the first embodiment, the heat exchanger plates 1 in the plate package 2 are permanently joined to each other through for instance brazing in a manner known per se. The plate heat exchanger includes a first inlet port 4 and a first outlet port 5 for a first medium, and a second inlet port 6 and a second outlet port 7 for a second medium.

Each heat exchanger plate 1 has in the embodiment disclosed a substantially rectangular basic shape and extends between a primary edge zone 11a and a secondary edge zone 12a in parallel with a central extension plane 13, an upper plate plane 14 and a lower plate plane 15, see Fig. 4. The central extension plane 13 includes a longitudinal centre axis x which divides the heat exchanger plate 1 in a primary part 11 and a secondary part 12. Each heat exchanger plate 1 also includes a first end area 16, a second end area 17 and a central heat transfer area 18. The central heat transfer area 18 extends between the primary edge zone 11a and the secondary edge zone 12a and from the first end area 16 to the second end area 17.

Each heat exchanger plate also includes four portholes 21, 23, which each extends through the heat exchanger plate 1. These four portholes 21, 23 in the heat exchanger plates 1 in the plate package 2 form the above mentioned inlet and outlet ports 4-7. The portholes 21, 23 are located at the two end areas 16 and 17, and form a primary porthole 21 on the primary part 11 of each of the first and second end areas 16, 17, and a secondary porthole 23 on the secondary part 12 of each of the first and

second end areas 16, 17. Each porthole 21, 23 is surrounded by a respective adjoining edge area 25.

Each of the first end area 16 and the second end area 12 includes distribution area 26, which extends over substantially the whole respective end area 16, 17 except for the portholes 21, 23. Each distribution area 26 has a base surface 27, which extends over substantially the whole distribution area 26. The base surface 27 of the distribution areas 26 is inclined in relation to the central extension plane 13 and is located at an upper level in the proximity of the upper plate plane 14 in the proximity of the edge area 25 of the primary porthole 21 and sinks successively to a lower level in the proximity of the lower plate plane 15 in the proximity of the secondary edge zone 12a. The base surface 27 of the distribution areas 26 also sinks successively along a border to the central heat transfer area 18 from in the proximity of the primary edge zone 11a to in the proximity of the secondary edge zone 12a. In the embodiment disclosed, the base surface 27 of the distribution areas 26 sinks continuously from the upper level to the lower level. It is to be noted that the base surface 27 also may sink gradually between successively lower levels which are substantially parallel to the central extension plane 13.

The distribution area 26 of both the end areas 16, 17, see Fig. 3, includes also a number projections 31 which project from the base surface 27 to substantially the upper plate plane 14, and a number of depressions 32, which sink from the base surface 27 to substantially the lower plate plane 15. Substantially each projection 31 extends along a respective path running from the primary porthole 21 towards the central heat transfer area 18. Substantially each projection 31 has, at least in a central part of the distribution area 26, a length which is substantially shorter than the distance from the primary porthole 21 to the central heat transfer area 18 along the direction of the projection 31 in question.

In a corresponding manner, substantially each depression 32 extends along a respective path running from the secondary porthole 23 towards the central heat transfer area 18. Consequently, substantially each depression 32 extends substantially perpendicularly to the respective direction of an adjacent projection 31, i.e. the directions of the projections 31 and the depressions 32 are substantially orthogonal in the points where these directions intersect. Also substantially each depression 32 has, at least in a central part of the distribution area 26, a length which is substantially shorter than the distance from the secondary porthole 23 to the central heat transfer area 18 along the direction of the depression 32 in question.

Substantially each projection 31 and substantially each depression 32 have two ends and two long sides. The projections 31 and the depressions 32 are arranged in such a way that substantially each projection 31, which is located on the secondary part 12, with one of the ends extends to one of the long sides of the depression 32 and substantially each depression 32, which is located on the primary part 11, extends with one of the ends to one of the long sides of a projection 31.

Furthermore, the heat exchanger plate 1 is symmetric with regard to the longitudinal centre axis x in such a way that most of the depressions 32 have a shape and a position which correspond to the shape and the position of a projection 31 on the other side of the longitudinal centre axis x. Thanks to such a symmetry and due to the fact that every second heat exchanger plate 1 in the plate package 2 is rotated 180°, each depression 32 will abut a projection 31 of an adjacent heat exchanger plate 1 in the plate package 2, see Fig. 4. This symmetry also means that the primary porthole 21 of the first end area 16 is located on the same side of the centre axis x as the primary porthole 21 of the second end area 17, i.e. both the primary portholes 21 are

located on the primary part 11 and both the secondary portholes are located on the secondary part 12.

It is to be noted that a few of the projections 33 and the depressions 34 along the centre axis x deviate from this symmetry since these projections and depression 34, respectively, have been divided in two shorter projections 33 and depressions 34, respectively, which from two directions extend to a respective depression 32 and projection 31.

Substantially all heat exchanger plates 1 in the plate package 2 are thus identical. In the fist embodiment, the heat exchanger plates 1 are also permanently joined to each other by any suitable method such as brazing. Each projection 31 is then permanently joined to a depression 32 of an adjacent heat exchanger plate 1.

The heat exchanger plates 1 have been manufactured through compression-moulding in one step from substantially plane plates. Preferably after the compression-moulding, the portholes 21-24 have been punched from the heat exchanger plates 1. The distribution area 26 of the end areas 16, 17 has thus obtained its shape through said compression-moulding. In the same compression-moulding step, also the central heat transfer area 18 has obtained the shape disclosed with two corrugations 36 and 37 of ridges and valleys, see Fig. 3. The corrugation 36 adjoins the first end area 16 and the corrugation 37 adjoins the second end area 17. The corrugation 36 includes ridges and valleys forming channels 38 extending obliquely over the central heat transfer area 18 from the secondary edge zone 12a to the primary edge zone 11a with an angle of inclination that is about 45° in relation to the longitudinal centre axis x. The channels 38 have a decreasing width in such a way that the channels 38 are wider in the proximity of the secondary edge zone 12a and taper successively when the channels 38 approach the primary edge zone 11. In the same manner the corrugation 37 includes ridges

and valleys forming channels 39 extending obliquely over the central heat transfer area from the primary edge zone 11a to the secondary edge zone 12a with an angle of inclination that is about 45° in relation to the longitudinal centre axis x, i.e. about perpendicular to the direction of the channels 38. Furthermore, also the channels 39 have an increasing width in such a way that the channels 39 are thinner in the proximity of the primary edge zone 11a and becomes successively wider when the channels 39 approach the secondary edge zone 11.

Fig. 4 discloses a section through the plate package 2. As appear a plate interspace 40 is formed between each adjacent pair of heat exchanger plates 1. The heat exchanger plates 1 are arranged in an alternating order in such a way that the primary part 11 in the first end area of a first heat exchanger plate 1 adjoins the secondary part 12 of an adjacent second heat exchanger plate 1. Consequently, the height of the plate interspace 40 will decrease successively from the edge area 25 of the primary porthole 21, 22 with regard to the first heat exchanger plate 1, or the edge area 25 of the secondary porthole 23, 24 with regard to the second heat exchanger plate 1, to the secondary edge zone 12a with regard to the first heat exchanger plate 1, or to the primary edge zone 11a with regard to the second heat exchanger plate 1. In the embodiment disclosed the heights of the plate interspace 40 decreases continuously.

In the embodiment disclosed, one of the media will thus flow into primary porthole 21 of the first end area 16 to the plate interspace 40 concerned and be distributed uniformly over the whole width of the plate interspace at the transition to the central heat transfer area 18. Thanks to the tapering channels 38 and thereafter the expanding channels 39 a uniformly distributed flow over the whole central heat transfer area 18 is ensured. At the second end area 17, the projections 31 of the

distribution area 26 will convey the medium to the primary porthole 21 where the medium leaves the plate interspace 40.

Fig. 5 discloses a plate heat exchanger according to a second embodiment, which differs from the first embodiment in that the heat exchanger plates 1 are pressed against each other between a frame plate 50 and a pressure plate 51 by means of tie bolts 52 in a manner known per se. The heat exchanger plates 1 have the same design as in the first embodiment with regard to the end areas 16 and 17 and the central heat transfer area 18.

The invention is not limited to the embodiments disclosed but may be varied and modified within the scope of the following claims.